Materialities shape practices and notions of comfort in everyday life

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Abstract

Development of residential energy technologies aims at ensuring thermal comfort in an increasingly energy efficient manner. This development influences everyday practices related to comfort in everyday life in dwellings. Therefore this paper analyses empirical examples from interviews with residents in three types of Danish detached houses, related to the building age, to zoom in on how changes in technologies influence residents' practices and notions of comfort. Detached houses are the most widespread type of housing in Denmark, constituting 44 per cent of the housing stock. The analysis focuses on differences in heating systems between the housing types and shows how changes in technologies and material structures shape practices of heating and airing. In terms of heating practices and the meanings of comfort, a shift in technology from radiators to underfloor heating was found to make a clear difference in how houses are heated and thermal comfort perceived. The paper concludes that changes in material structures of houses consequently change residents' perceptions of comfort and the related everyday practices. The paper furthermore contributes by nuancing notions of comfort in relation to different practices, and specifically the relation between airing and heating practices, as well as the context of seasons and the outdoors.

Keywords

Comfort, social practices, space heating, housing, everyday life, energy consumption

Introduction

Building regulations continuously prompt changes in the physical structure of housing and the energy technologies that sustain dwellings with for example heat, together with technological development and norms of comfort. With a growing focus on energy efficiency and sustainable buildings, specific quantifications of thermal comfort are regulated in terms of how to achieve comfort with the lowest energy consumption. This is reflected by a strong focus on energy-efficient technologies that presuppose a rational behaviour by residents. In Denmark, and most other EU countries, this approach has succeeded in lowering the heat consumption per square meter in newly built housing, hence the overall consumption of heat in Danish housing has not decreased significantly.

Studies have shown that the energy consumption of dwellings varies with differences in households' practices. This shows that houses do not operate in a vacuum, but are highly influenced by, and influences, the residents living there and the everyday practices that are carried out (Gram-Hanssen, 2010; Gram-Hanssen & Hansen, 2016). Shove (2003) has established that the concept of comfort is a socio-technical issue in showing how

conventions of comfort are shaped by standards of building technologies together with, among other things, policy and everyday life. These perspectives suggest that matters of comfort and energy consumption are not solely related to questions of economy and technologies, as notions of comfort change with material and social structures as well as social practices such as heating (Strengers 2011, 2013). Shove and colleagues (2012) have put focus on how elements that constitute social practices; materials, meanings and competences, equally take part in both characterising practice entities and in changes to how practices unfold. This paper looks into how these changes and differences unfold, through an empirical study of household practices in detached houses in Denmark. By unfolding examples of how notions and practices of comfort change with energy technologies and competences, the paper reveals insights into how material structures of housing influence comfort.

Against this backdrop, this paper examines empirically how notions of comfort are manifested between building schemes and everyday life in homes, and what this means for energy-efficient housing. The notions of comfort in detached houses are scrutinised in a nexus of materialities, routinised activities, bodily senses and social norms by zooming in on residents' practices, perceptions and sensations of comfort in three types of detached housing. The three housing types denote three time periods of building regulations in Denmark; however within a short time frame of about 40 years. The paper starts with a short introduction to theories of social practices and the literature on comfort and energy consumption within this framework. The background and methods section briefly introduce the Danish Building Regulations and Danish detached housing as well as presenting the methods used and the empirical data comprising interviews and photos.

Social practices of comfort and energy consumption

The everyday life can be described as the cohabitation of objects, people, feelings and activities in the setting of the home (Löfgren 2014).The aim of this paper is to scrutinise this relation between the social everyday life and the technical and material structures of home heating to focus on the nuances of comfort practices and how these are influenced by changes in energy technologies. For this purpose, a practice theory framework is useful because it interrelates the social and the material in analysing social practices as central to understanding social phenomena, such as comfort (Reckwitz 2002; Shove et al. 2012; Warde 2014). Practice theory addresses relations between humans and objects in everyday life; or between elements constituting practices such as materials, competences and meanings, as named by Shove and colleagues (2012). Social practices can be seen as coordinating entities, as for example the practices of heating and cooling, that are shared across space and time through common understandings (Schatzki 1996). Schatzki distinguishes between this practice entity and the performance of practices, which is the way individuals carry out specific practices, implying that there can be individual differences in how shared social practices are performed, according to material surroundings and practical understandings. Practice entities are realised and sustained by this performance of practices (Warde 2005; Schatzki 1996; Shove et al. 2012).

The practice theory approach has been used to understand thermal comfort as enmeshed with energy-consuming practices configured by material environments. Within this research, comfort practices have been related to thermal comfort including practices of heating and cooling (Chappells and Shove 2005; Day and Hitchings 2011; Gram-Hanssen 2010; Hitchings 2011; Jalas and Rinkinen 2013; Rinkinen and Jalas 2016; Judson and Maller 2014; Shove 2003; Shove et al. 2008; Strengers 2008, 2011, 2013; Strengers and Maller 2011; Wilhite et al. 1996). Strengers describe these practices as the activities residents undertake *"to heat and cool their bodies and homes"* (Yolande Strengers 2010: 7313). This body of research has established that residential comfort and energy consumption are greatly influenced by the everyday practices of residents in housing. For example, Gram-Hanssen (2010) showed differences in how comfort is practised within similar material settings of housing, with households that represent varied social configurations of meanings and know-how. Hitchings (2011) showed how office workers' practices related to thermal comfort should be understood in an interaction between elements such as embodied sensibilities (clothing), habitual modes of thought (social contexts) and physical infrastructure (ambient environments). For example, the indoor office environments with standardised air-conditioning, meeting and lunch facilities meant that employees dressed, habitually, for that specific ambient environment rather than for the seasons and weather outside. Strengers showed how dynamic peak pricing did not significantly change social practices of cooling in Australia, although these practices were performed in diverse ways and could shift across space and time, according to the context the householders' everyday life. Strengers and Maller (2011) further showed, among other things, how residents' adaptive strategies of cooling practices in hot weather were enabled or restrained by the material design of the house including the housing structure such as bricks, shadings and windows or indoor technologies such as air-conditioners or fans.

Additionally, there is a growing focus on how energy-consuming practices related to comfort are constituted within the house-as-home comprising both material and social elements (Aune 2007; Ellsworth-Krebs et al. 2015; Rinkinen and Jalas 2016). Rinkinen and Jalas (2016) studied how the house as a material artefact and a domestic sphere forms the heating practices of new residents. This paper adds to these research strands by investigating how differences in material structures and energy technologies in different types of detached houses, as outlined in the next section, form the residents' perceptions and practices of comfort in the home.

Background and empirical data

In the years 1960-1980, around 450.000 detached houses were built in Denmark, which nearly doubled the housing stock. In this period, the housing sector also became strongly industrialised and many standard houses were built from standard designs and prefabricated elements. The construction of new detached houses decreased in the 1980s and into the 1990s. The standard detached houses built during this period does not differ

much from earlier houses in their general design, reflecting quite strong conventions of aesthetics and building techniques (Lind & Møller 1996). Most detached houses, 40 per cent, are heated by district heating which has been the dominating energy supply for heating since the 1980s (Statistics Denmark 2016). The technologies that are linked to district heating are typically radiators or underfloor heating. The Danish Building Regulations outline the legal requirements governing all types of buildings in Denmark. It contains requirements on topics such as layout, services, indoor climate and energy consumption. The objective of the subject of indoor climate is that buildings should be built so that when using the building for the prescribed purpose, there will be a sustained and satisfactory healthy and safe climate including comfort (The Danish Transport and Construction Agency 2015). This comprises thermal indoor climate, air quality, acoustic indoor climate and lighting conditions. Since 1979, the Danish Building Regulations include provisions on how to improve the energy efficiency of the built environment and reduce the energy consumption. Over the years, the energy requirements have changed from regulating the performance of building elements to regulating energy performance of the total building, including energy production (Gram-Hanssen 2014).

The empirical data comprised in-depth interviews including home tours and photos from a field study on the outskirts of Aarhus, Denmark's second largest city. The study included two rounds of interviews in the participants' homes during the heating season, comprising 17 interviews. The first round included 14 interviews in different households, either with one or both partners of the household[1] (see table). The second round was a photo-elicitation study including a follow-up interview conducted with three of the participants. Interviews were transcribed and analysis software was used to support the empirical analysis of coding interview quotes into themes of comfort, home and energy consumption as well as sub themes.. The analysis in this paper builds on all interview material, including photos by the author, and was developed through an iterative process of reading the coded interview material, where an interesting pattern appeared when these were grouped into housing types. Quotes have been translated from the original Danish into English by the author. The three groups of housing were subdivided by building age (see table). This subdivision reflects changes in the Danish Building Regulations, for example regarding heating systems and insulation. All households in the study were connected to district heating; thereby households with other primary types of heating were left out. Further all houses, except one, were owner-occupied, as are most detached houses in Denmark (Lind & Møller 1996). This reflects specific heating practices and a specific urban housing context, both socio-economic and geographic. The participants varied in relation to gender, age and family types (see table) but they represent a rather homogeneous socio-economic group characterised as being from lower to upper middle class. The study did not aim to resemble a representative study; however, a group varying in relation to gender, age and family structure reflect a more varied picture of heating practices within this specific type of housing.

[Table 1]

[1] All interview participants have been given pseudonyms to secure anonymity.

Perceptions and materialisations of comfort in detached houses

The analysis of this paper focuses on practices that relate to thermal comfort in a Scandinavian climate, notably heating and airing. It is explored how these practices are shaped through changes in heating technologies and material structures of the three different house types.

Detached houses from 1969-79

The houses built from the late 1960s to the late 1970s are typically heated mainly by radiators with a thermostat and often with underfloor heating in the bathroom. These heating technologies can also be supplemented by other heating devices.

Heating and airing: a variety of technologies and practices

In the older houses, there were multiple technologies involved in heating, as Helene explained:

"(...) we only have that radiator turned on [in the kitchen] and then there's one in the bathroom, it's on two and I also think the underfloor heating is on there, that's all we have turned on, because we have a wood stove and then we have that heat pump in there [the living room] (...) that one [radiator in the kitchen] is only turned on if we're out here, otherwise there's obviously no need and then we turn it off when we fire up the wood stove (...) [the heat pump] we actually only turn on when we don't use the wood stove, otherwise it's not turned on and there's no heat anywhere else" (Helene, 40s).

This heating practice is quite complex involving radiators, underfloor heating, a wood stove and a heat pump. Helene and her husband rented a big house and a large part of it was not heated at all. They mainly heated rooms when they used them, mostly the kitchen and the living room, and the bathroom was kept warm with both a radiator and underfloor heating. They owned a company and worked from home, which involved their employees walking in and out of the house. They had 'inherited' the heating installations and technologies that came with the house, when they moved in recently. Their heating practice involved turning on and off the different devices as they moved around the house

during the day. Most of the participants living in older houses owned and used a wood stove. Sarah explained that they used a wood stove in winter, because otherwise the house could not be heated sufficiently:

"*In the winter months we use it from October to March (…) now the weather is good but otherwise we use it every day in the winter (…) when it's on the radiator turns itself off, it's not like we turn it off, it regulates itself (…) even though the radiator is turned on, if the wood stove is not fired up then it gets very cold" (Sarah 40s)*.

Sarah and her husband lived with their teenage daughters in a house which was not well insulated. She found it was difficult to heat the house when it was cold outside, especially the hallway felt ice cold and therefore they had placed a carpet. In winter, they used the wood stove as a supplement to the district heating and radiators when they arrived home from work. Moreover, they had underfloor heating in the two bathrooms, which Sarah enjoyed. Thereby several heating technologies, and a carpet, were used to keep the house warm. Another participant, Maria had immigrated to Denmark together with her husband and lived in a house with two levels together with two of their three grown-up children. She explained that they hardly ever used their wood stoves. They did not need them in their heating practice, because they felt that the house was well insulated and easily heated to satisfy their needs:

"*We have two wood stoves, here in the living room and then one in the basement. But the one in the basement we've used only maybe two times, in all fourteen years, because it gets very warm, and the basement is very well insulated, the children don't use any heating downstairs (…) the heating pipes, they're in their rooms, so you know, when the heating is transported, it gives a lot" (Maria, 50s)*.

Maria explained that when the heating was turned on it ran through pipes in the basement and heated the downstairs rooms. The heating technologies of these older houses were closely related to practices of airing, as the radiators and the wood stoves were involved in different ways in how houses were aired. This connection, between technologies and heating and airing the home, was partly because airing was used to regulate the heat in the house, although this was more pronounced for participants in newer houses, but also because airing affects the function of heating technologies like radiators. This was most pronounced with the participants in these older houses, where the knowledge and routine of turning off the radiators when airing the house, in order not to waste energy and control the temperature was apparent: *"when I air I turn off the radiators and then when I close I turn them on" (Maria, 50s)*. Airing was often performed daily, for example in the mornings, and all of the participants living in this housing type spoke of the importance of turning off radiators when the windows were open and turning on the radiators when they were closed again. Practices of heating were also related to practices of airing in the issue of smells; for example how the heating technology of a wood stove affects the indoor climate in a house. Helene explained that she airs the house a lot, especially the living room and the kitchen through the terrace door: *"(…) it's the first thing I open (…) when I get up, but that's because I don't like that smell from the wood stove" (Helene, 40s)*. In general, Helene was concerned about the smell in the house and about letting in

fresh air, because there were many people and a lot of smoking during the day.Therefore she would rather put on another sweater if she felt cold, than not opening the door.

Heating and airing: sensing warmth and cold

The relation between heating and airing is also a relation between warmth and cold, as airing affects the temperature in the house and can be used to adjust this. Warm and cool were further sensed and perceived through the material structures of the house, as explained in different ways by the participants. Maria felt the house was well insulated and easy to heat because of the walls: *"When we have turned down the heating in here, you cannot feel that the walls are cold, it's well insulated" (Maria, 50s)*. Feeling that the walls were not cold, she also felt that the house was not too cold. She further found the basement well insulated, because on the one hand is was easily heated through the uninsulated pipes, but on the other hand it also kept out the heat in summer, and she explained that as a consequence they sometimes slept in the basement, when it was too hot upstairs. Pink and colleagues (Pink et al. 2013) similarly showed how sensory perceptions of cold and warm shifts the everyday practices of family life around the home, according to seasons, as some rooms might be either too cold or too hot.

Erik and Karen, a couple in their sixties, explained how their old house differed much from the newly built low-energy house in which they had been living for a year, especially when it came to draught and thermal bridges, which is a common problem in the Danish standard houses of the 1960s and 1970s (Lind & Møller 1996). In their old house they could feel the warmth and cold of the seasons changing, as Karen said: *" (…) in the winter, we could feel right away when it was really cold and we could feel in the summer when it was warm (…) And this, we don't feel that change so strongly, because it's well insulated" (Karen, 60s)*. And Erik explained how the cold could be felt in the materials of the house: *"The floors in a house like the one we lived in before, they're cold, because there was a crawl space underneath (…) and when you sat reading underneath the windows, you'd be cold, because the cold gets in through those double-glazed windows from the 60s and the 70s" (Erik, 60s)*. Karen further explained how this affected their sensation of the floor and their practice of decorating: *"In the winter in the bedroom, we didn't have a rug in there, we had a nice floor (…) it was icy cold when you got up…and in the living rooms we kept the carpets for a long time after it had become fashionable to take them off" (Karen, 60s)*. In this way, Karen and Erik described how their perception of heating in their old house was materialised in the walls, windows and floors of the house, which they felt especially in cold winters and how a carpet could be an element in creating comfort.

Heating was closely related to the insulation of the houses as some participants felt their houses are well insulated and easy to heat with radiators and some participants felt colder and draught in winter. Therefore they used both carpets and wood stoves to obtain a comfortable temperature. The heating practices were characterised by an embodied know-how of regulating the heating between cold and warmth as well as fresh air. Cold and warm were sensed with the body and in the material structures of the house such as the

walls and the floor that are elements in an on-going evaluation of the indoor temperature. Such sensory knowhow in heat management was also studied by Royston (2014) demonstrating how several of the human senses were used to define a comfortable temperature in a house. Different senses were used in airing and heating the houses and these practices were interrelated. Airing was used to cool down the house or to rid it of bad smells and connected to the heating technologies, either because the wood stove produced smell or because airing affected the function of the heating technologies, such as radiators starting to overheat.

Detached houses from 1997-2001

The houses from the late 1990s and the early 2000s typically have underfloor heating with thermostats placed throughout the house.

Underfloor heating: sensing and practicing

Camilla and Behram, who lived with their young boy and were expecting a baby, were very fond of the underfloor heating in the house, as Behram noted: "*Especially when having a little one crawling, then it's nice" (Behram, 40s)*. In this way, the material structure of the home and the heating technology of underfloor heating was connected to family life and creating a comfortable environment for a child. Further, Behram also enjoyed the even heating and comfortable temperature of the house, throughout rooms and seasons, which was why he would be wearing a t-shirt all year round. Many of the participants said they enjoyed the heated floors: *"it's lovely, it's wonderful to walk on the warm floors" (Marianne, 60s)*. Marianne explained that she could feel the warmth through her socks, also in the spare bathroom where the heat was turned down a bit, and in this way she estimated that the room would be heated enough for guests. She added that her feet would always be freezing cold when visiting friends living in older houses from the 1970s, though she had herself lived in such a house before. The participants agreed that the underfloor heating supplied a comfortable and even heating, as it ensured 'warm feet'. When Birgitte, who lived with her husband and one of two grown-up children, compared the underfloor heating in their house with the heating of older houses by radiators and wood stoves, she said:

"(...) we have the heat from below, that you're warm around the feet (...) at my mother-in-law's who live in an old house, she has a wood stove and radiators, and (...) even though it's warm, then it's warm up here and cold down at the feet" (Birgitte, 50s).

Underfloor heating was perceived as a comfortable way of heating the home, and the participants living in these houses rarely talked of being too cold in the house, compared with the participants in the older houses above. Heating is practised in more identical ways by the participants living with underfloor heating, as there are less scope for regulation with this technology and it is most often the only heating technology in the house. Several of the participants seldom regulated the heating, either because they did not find it necessary or because it was too complicated:

"(...) we don't turn the underfloor heating up or turn it down (...) it just runs (...) every room has its own thermostat, so you can regulate, but I'm not really sure about, and I know you should be careful, because if it gets cooled down then it costs more to warm it up" (Behram, 40s).

Behram and other of the participants were not sure how to operate the heating system in their house, which was why they simply did not regulate much. Birgitte further explained: *"it's so inconvenient to regulate, simply because it's in the back of the cupboard and you need to go in with a tool and screw, so we don't, then of course we open doors and windows" (Birgitte, 50s)*. Because it was too complicated and inconvenient, Birgitte stated that if they felt warm in the house, they would rather air than turn down the heating. However, she also felt that it was easier to control the temperature in this house, than in a house with radiators, especially in relation to airing because radiators would start overheating if they were not turned off. Underfloor heating was in some ways seen as a complicated technology that it was difficult to regulate daily, but in other ways it was also experienced as simple:

"We don't really regulate that much, we just leave it, we regulate the rooms where we don't spend so much time, we turn it down, also in the bedroom (...) we don't really touch it much, so I think it's easy [laughs]" (Pernille, 30s).

Pernille found this heating technology simple because she did not feel the need to regulate much, and still she could keep lower temperatures in specific rooms. As such, they did not regulate the heating frequently, as they had done with radiators in an earlier home. One inconvenience that more of the participants talked about was the delayed reaction of the system when regulating the heat up or down, which meant that the change would be felt around 24 hours later. Therefore the participants would often not regulate the heating when they felt too cold or to warm, or when using rooms that were not used on a daily basis. Claus explained:

"(...) we don't do night-time drop on the heating, and neither do we lower the temperature 1 or 2 degrees when travelling, we leave it, and then it's comfortable to say; well, then you maybe save 100-200 DKK and then you need to heat it up when you return, and then what was the setting (...) we keep the status quo (...) it's easy and convenient and that's also comfort" (Claus, 40s).

Claus found the long reaction time of the heating system very inconvenient and therefore he did not bother to regulate the heating frequently or when the family went away. He lived with his wife and two teenage children and explained that he cared more about comfort than saving a little money.

Underfloor heating: practices between seasons and rooms

Claus further explained how it could be difficult to regulate the heating when the weather changed:

"(...) it's concrete floor all over and that means that when you turn the heating up, then it needs to warm up all of that concrete before you get the heat (...) you also have a problem, when you have spring/autumn, then if you have a warm summer day it gets really warm, because it also takes 24 hours to cool it down again" (Claus, 40s).

In this way the technology and the materiality of the floor together created an inconvenience in Claus' heating practice and difficulties of adjusting the heating when seasons were changing. Though most of the participants did not regulate the heating daily, there was some regulation around the summer season. This regulation often included a gendered division of tasks, like for example in Camilla and Behram's case:

"C: No, I never regulate the heating, its Behram's responsibility, when I start chattering teeth and freeze and say; now you need to turn on the bloody heating again, then you do it. B: Yes, but I usually only do it for three months during summer (...) the house is so warm because it's almost sunny for 24 hours" (Camilla, 30s & Behram, 40s).

Behram would turn off the heating during summer and it was also his task to turn it on again when summer was over. This household division of tasks related to heating was also reflected in several other interviews, while some participants said that this division had been opposite, when they lived in a house with radiators. In summer, the sun would often help to heat the house, as Pernille explained: *"(...) here [kitchen-dining area] and in the living room (...) as soon as the sun shines it gets pretty warm, and then I think it turns off when it gets passed a specific temperature" (Pernille, 30s)*. At the moment, Pernille and her husband did not use all of the rooms in their house; however, they were expecting a baby and anticipated to use all rooms in the future. They primarily heated the open-space kitchen and the living room where the sun also had an impact, while they seldom regulated the thermostats, but mostly kept the same temperature setting. The bedroom they preferred to be cool. Several participants aimed at having different temperatures in different rooms of the house, according to their use. For example in Marianne's case:

"(...) it's on 23 degrees in here [living room] (...) that's in winter, in summer I turn it down to zero (...) then I have 15 degrees in the bedroom, and in the same way 23 in the bathroom, in there [spare room] I have 20 degrees, because I'm never in there (...) and then the office in there, it's also 21 (...) if it's cold I'd rather close the door in there, and then out where you came in [hallway] it's also 21, and the guest bathroom out there, it's also 20-21" (Marianne, 60s).

Marianne was very aware of the temperature settings in the house and tried to adjust the heating to her needs, living alone in a house where she did not use all of the rooms. She was interested in trying to save money on heating, which is why she wanted to keep the

temperature low in the rooms she did not use, and had started to put on a sweater in winter instead of turning the heating up if she felt cold. The underfloor heating in these houses supplied a bodily sensation of comfort through the warm floors. The heating practice was simpler as it only included one type of technology, however this technology could be complicated to use. Therefore, with the underfloor heating the residents did not regulate much compared to the older houses with several heating technologies.

Low-energy houses from 2012-13

The new low-energy houses typically have underfloor heating, and in this way share the same heating technology as the houses above. However, these houses have a tighter building envelope often combined with mechanical ventilation with heat recovery.

Heating practices: between warmth and cold

The participants living in low-energy houses were quite content with their heating system, even though they sometimes had troubles regulating and adjusting it. The houses were perceived as satisfactorily warm in general, although even if the house was suitably warm, the floors would sometimes feel cold, as Jacob explained:

"(...) in a more leaky house (...) then you go out into the bathroom and the floor is heated (...) when you come into a new well insulated house here, then the floor is not warmed in the bathrooms (...) the heat cannot leak out and that's exactly what it would do in a more leaky house, so it was like the reverse, you didn't have that nice bare feet on the bathroom floor" (Jacob, 40s).

Jacob lived with his wife and four children in a large two-storey house, which they had designed themselves. He described how moving into the newly built house had changed his perception of comfort in the bathroom, so that he now wore slippers. For the bathrooms, a part of the comfort feeling was connected to warm floors, which are not possible to have in the tight houses. Another participant, Kasper, also found it difficult to adjust the temperature, as he would like the floors in the house to feel warm and not cold as they did sometimes, because the heating control turned off when the house was heated sufficiently. This reflects a different bodily perception of warm and cold compared with

the older houses with underfloor heating. The participants appreciated the tight houses though, as there was no draught. Jacob said that they could use more of the space in the house, because it was possible to sit close to the tight windows as opposed to their old house. Erik also explained this difference:

"Before we sat in front of a window and felt the cold, and we could feel the cold in the floor too (...) We can't here, it's pleasant when it's cold outside; now we're going home to our comfortably warm house" (Erik, 60s).

In general, the participants were happy with the heating of the houses, and did not talk much about problems of overheating. However some of the participants did say that the sun had a big effect on heating the house. Jacob noted that he appreciated feeling the sun warming the house, especially in the spring: *"It's 25 degrees in here now, and I could open a window, but I haven't done that yet, but maybe it's because it's so early in the spring that you're just delighted in the warmth" (Jacob, 40s)*. This demonstrates another perspective on how the seasons and warmth are felt in different houses. This house had an overhang, which protected most of the house from overheating in the summer. However, the temperature could sometimes rise quite a lot in these houses, when the sun was out or when having guests and candles were lit, as Tilde explained:

"(...) if we have many guests then it can get warm, because the house is so tight, of course it also has an effect, now I lit candles today, because it was so dark this morning, it heats a lot in a house like this" (Tilde, 30s).

This explained how materials and practices that were not directly linked to the heating practice affect the heating of the house. Tilde lived with her husband and two young children in a newly built house, which they had designed themselves. She commented that they had decided their house should face north in order to avoid overheating, and she added that some neighbours had the curtains drawn all the time because the house would get too warm. Erik explained how they had to take care on sunny days:

"In the summer, we have to be very careful that we have pulled the curtains a bit, at the large windows in the kitchen-dining area and the living room, because otherwise it gets too warm in those rooms (...) it can also be necessary to do some extra airing in the morning" (Erik, 60s).

In this way, the close relation between heating and airing was also connected with the changing of seasons. Erik's wife, Karen, further explained that airing was easier in this house, because you could air without regard to the heat controls, as this heating system would not start accelerating because of cold air. Airing and ventilation systems were important for these participants, as the tight house, which provided a comfortably warm indoor temperature most of the year, also meant that the houses needed to be aired. Kasper said that they would open the window in the bedroom in the evening to cool it down before going to bed, as it was difficult to keep the temperature low, which they preferred. Accordingly, practices of airing and heating were again interconnected. In general a mechanical ventilation system was needed as explained by Jacob:

"(...) there's mechanical ventilation with heat recovery…we knew for sure that we wanted that, both because we would not be good enough at airing (...) a tight house, it's simply the recommendation to have that (...) but also there's no doubt that it's an amenity…and at the same time it's nice that when it's warm outside to be free to open windows and doors and get the fresh direct air inside (...) another contact with the garden" (Jacob, 40s).

This explained well how the low-energy houses of the interviewed participants provided a comfortable indoor climate most of the time, with technologies in practices of heating and airing, but at the same time it showed how the manual possibilities were important to the everyday home-making of the participants, for instance by sensing the outdoors. Hauge (2013) has similarly showed how 'the air from outside' is evaluated by bodily sensations and provide social and cultural meaning in airing practices of Danish households.

Heating practices: between senses and technologies

In general, the participants would have their temperature settings at around 20-22 degrees, which they felt was comfortable and normal: *"It's probably not something I think much about, I think it's pretty standard that you have around 21 degrees in a house" (Kasper, 30s)*. In the newer houses, the participants were more aware of temperatures and in the low-energy houses the heating technologies had an explicit role in the daily heating practice, because digital thermostats were visible in each room. The participants focused a lot on the temperatures shown on their thermostats placed around the house. Jacob said they had thermostats in all rooms of the house and this was an important factor in controlling the heating. He explained that they could follow how warm it was in the house, so even though they would have the same temperature setting on the thermostats most of the time, they served as a check to see if the house was warmer or colder than the desired 20 degrees:

"We often look at it, because (...) you can say; oh, it's a little cold in here, then we go and have a look and read off the temperature digitally, it's 21.5 degrees, you trust the number it says and adapt to it – how do I feel in relation to that number (...) I wonder how much difference it would actually be if you had the same control, just without the display" (Jacob, 40s).

Jacob explained how the thermostat technology provided the possibility of comparing bodily sensations with technological facts in the practices of heating and airing; for example if it got too warm in the summer and they needed to open some windows. Or during a cold spell in winter when the house was somewhat colder than usual; then they could put on a sweater, when feeling cold before leaving the house in the morning reassured that it would be sufficiently warm later on, as Jacob said. Erik also watched the thermostats and was content with the heating system, as the temperature did not differ much from the setting:

"When you get up on a cold winter morning, even though it's minus 20 outside then you have the temperature you need in here…of course, sometimes if it's really cold outside

you can see that maybe the temperature is 0.4 degrees lower in the kitchen-dining area than it should be (…) but we don't feel it much" (Erik, 60s).

Erik observed the small variation in indoor temperature, which he said they did not sense too much. In this way, the thermostats played an active role in the thermal comfort of the residents in low-energy houses as they compared their bodily sensations of warmth and cold with the temperature on the thermostats and adjusted their heating practice accordingly. The technologies of the low-energy houses influenced the sensing of warmth and cold in the home by the participants which were related to the material structures of the house, such as windows and floors, and to the changing seasons. In the low-energy houses warmth and cold, light and air, was connected in new and different ways, compared to the older houses, through the residents' bodily sensations, the technologies and the notions of comfort.

Concluding discussion

The analysis showed how the different materialities and technologies in the three groups of houses shaped the heating and airing practices of the residents in different ways, through their everyday life. These practices were part of a complex web of everyday practices entailing the materials and technologies of houses, embodied know-how or competences, bodily sensations and social meanings of comfort. In this way the notions of comfort were embedded in the material structures and interpreted through bodily sensations. A clear difference was found between the oldest detached houses, heated mainly by radiators, and the newer houses with underfloor heating throughout the house. This shift in heating technology changed the residents' heating practices and meanings of comfort; how warmth and cold were experienced as comfortable for example through the floors. For residents living in older houses, the daily heating routine was more varied involving different heating technologies and turning on and off the devices according to their daily practices; especially in winter different heating technologies were used to create a comfortably warm indoor temperature. Jalas and Rinkinen (2013) similarly noted that wood heating is an everyday practice of comfort that reflect daily and annual cycles, such as seasons, thereby underlining how wood as a heating technology forms rhythms of everyday life.

The analysis in this paper showed that underfloor heating, both in the bathroom of the older houses and throughout the floors of newer houses characterised a bodily sensation of warm feet, which was a strong comfort notion induced by heating technology. This comfort aspect lacked in the low-energy houses, where the material structure would not allow for a floor heated to a level, where the warmth can be felt in the floor material. However, the even heating of these houses was still perceived as comfortable. In some cases, the heating technology did not need much regulation, and therefore might be perceived as a simple technology. However, the knowledge of regulating the underfloor heating was also perceived as more complex, as some participants found it difficult to adjust it to their needs continuously, while these needs changes with daily activities and seasons. The bodily know-how of regulating the heating technology was less apparent in

the newer houses, where the technology was seen as complicated and in some ways took over the heat regulation, and definition of comfortable temperatures, from the participants. The materials of the house, and the layout, were also issues with this heating technology, as some materials are more difficult to regulate and the rooms of a house are used for different activities at different times and do not necessarily need the same temperature. Therefore some participants found the radiator to be a more simple heating technology, which prompted a more frequent regulation of the heating.

In the older houses, the participants differentiated between temperatures in different rooms, depending on what the rooms are used for and how often they are used. The idea of a cold bedroom to sleep in is apparent with many participants across older and newer houses; however, it is more difficult to keep a cold bedroom in the low-energy houses, where the heating is even. In the standard estimations of comfort in housing, it is expected that all rooms in a house are heated in the same way, which also assumes that residents will have the same thermal comfort needs in all rooms, notwithstanding the different everyday activities that are carried out in the rooms. This analysis of everyday practices related to comfort showed that residents like to differentiate the temperatures in the different rooms throughout the house, although they also appreciate the even heating of the underfloor heating technology. The even heating and lack of draught in the new houses created new possibilities for using the house, as the participants did not feel cold when sitting close to windows and walls. Differences in insulation and ventilation systems of the houses also influenced the comfort perceptions, especially as the sensation of warmth and cold were intimately connected, which further related heating practices with airing practices. Practices of airing were also connected to comfort in creating a relation between the indoors and the outdoors, by letting in fresh air. The seasons and the weather were felt differently in the different housing types; in the older houses outdoor cold temperatures and wind was felt strongly, whereas in the newer tight houses the heat from the sun was felt more. The changing seasons of the Scandinavian climate and the outdoor environment showed to have a strong influence on how comfort was perceived and practised within the home. Hitchings and colleagues (2015) have also studied how the perception of comfort in relation to the changing seasons were induced by cultural notions of seasons and weather, of warmth and cold, in an Australian climate. Such cultural notions of seasonal comfort must be taken into account to understand the context-bound everyday comfort in housing.

In conclusion, the analysis demonstrated how comfort was practised and perceived by residents in different types of detached houses in relation to the material structures and technologies. This showed that practices of heating and airing were closely connected. Furthermore, it showed how materialities and technologies figured in these practices together with the competences or know-how of how to operate the technologies, or manual ways of attaining a comfortable indoor temperature. This was further linked with the meanings, or notions, of a comfortable temperature in the home as related to different everyday practices. In addition, notions of a comfortable home, related to temperature as well as fresh air and layout of the house, were found to be connected to the material structures of the housing types. Accordingly, the analysis showed how notions of comfort

are materialised in dwellings and thereby how changes in building standards influence residents' perceptions and practices of comfort.

The differences in material structures of housing and technical installations, reflected in changing building regulations, formed the heating and airing practices of the residents. These changes in practices revolved around perceptions of comfort that did not necessarily match an efficient energy consumption of the house types, and that were furthermore enmeshed with other practices related to comfort as well as other energy-consuming everyday practices. The changes in practices and notions of comfort were shown in developments in housing types within a rather short time frame of about 40 years. It is important to understand such differences to understand what happens in houses-as-homes, when technologies and building structures are changed aiming for more energy efficient housing. Practices change with the development in material structures and technologies, but also with the competences to operate the house and meanings of a comfortable home, which develops in relation to other societal changes in for example family forms, welfare and prosperity. Accordingly, the development between the three housing types as reflected in the Danish Building Regulations also reflects developments in expectations to standards of houses, and these expectations do not necessarily match the visions of energy efficiency in housing. This analysis demonstrated how practices related to comfort are formed by developments in materials and technologies, as notions of comfort are embedded in these. This understanding of the relation between social and material structures in perceptions of comfort contribute to ways of understanding the scope of changes in material structures of housing, and how these can undermine or support the energy efficiency of dwelling. This insight indicates that there is scope for building standards and policy to influence energy-consuming practices related to comfort by incorporating a more holistic understanding of the comfortable home. For example, the relation between heating and airing suggest that these practices and their related sensations, competences, technologies and meanings might be thought about in a more close connection in housing design: both of these aspects are essential to feeling comfortable in a home but they also sometimes oppose each other.

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Table 1. Overview of participants and house types in the field study.

Participants	**Ownership**	**House type by year**	**Heating technology**	**Gender**	**Age**	**Household type**
Helene	Rented housing	1969-1979	Radiators, floor heating, wood stove, heat pumps	Female	40s	Couple, no children at home
Birte & Peter	Owner-occupied	1969-1979	Radiators, floor heating	Female & male	60s	Couple, no children at home
Maria	Owner-occupied	1969-1979	Radiators, floor heating, wood stoves	Female	50s	Couple, 2 children at home
Sarah	Owner-occupied	1969-1979	Radiators, floor heating, wood stove	Female	40s	Couple, 2 children at home
Marianne	Owner-occupied	1997-2001	Underfloor heating	Female	60s	Widow, no children at home
Claus	Owner-occupied	1997-2001	Underfloor heating	Male	40s	Couple, 2 children at home
Pernille	Owner-occupied	1997-2001	Underfloor heating, wood stove	Female	30s	Couple, no children yet
Camilla & Behram	Owner-occupied	1997-2001	Underfloor heating	Female & male	30s & 40s	Couple, 1 child at home
Birgitte	Owner-occupied	1997-2001	Underfloor heating	Female	50s	Couple, 1 child at home
Linda	Owner-occupied	1997-2001	Underfloor heating	Female	40s	Couple, 3 children at home
Jacob	Owner-occupied	2012-2013	Underfloor heating	Male	40s	Couple, 4 children at home
Kasper	Owner-occupied	2012-2013	Underfloor heating	Male	30s	Couple, 2 children at home
Tilde	Owner-occupied	2012-2013	Underfloor heating	Female	30s	Couple, 2 children at home
Karen & Erik	Owner-occupied	2012-2013	Underfloor heating	Female & male	60s	Couple, no children at home